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ABSTRACT

Research in the school library field has shifted from the traditional focus of document storage and organization to the actual use of information in the context of the user's problem-solving. Information skills as learning tools contribute to students' ability for thinking, problem-solving, and creativity. This paper looks at how the integrated curriculum contributes to the enhancement of students' creativity. The paper investigates: creativity and intelligence; evidence of integration in human cognition; Jean Piaget's schema theory; the function and structure of the cerebral cortex; the function of tools; Vygotsky's mediation theory; the information processing model--a tool to aid creativity; integrating characteristics in an information processing model; and characteristics in an information processing model as a tool. Information processing models are necessary tools to enhance students' creativity. Creativity, the purpose of education, comes from the integration of different information which exists both in the human thinking process as well as the information processing model when it is used. Since the integration of different information is critical in generating creativity, it is necessary for students to be exposed to a multi-information environment. The multi-information environment for students means an integrated curriculum which includes library and information skills and one or more subject areas. (Contains 61 references.) (SWC)

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Necessity of Information Processing Models as Functional Tools

By:

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Necessity of Information Processing Models as Functional Tools

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1. Introduction

The research tendency of the school library field shows a shift from the traditional focus of the document storage and organization to the actual use of information in the context of the user's problem-solving. This shift is very natural in order to cope with the pursuit of educational purposes in which the student's creativity is the foremost priority. It is true that library and information skills (hereafter, information skills) as learning tools contribute to students' ability of thinking, problem-solving or creativity.

As our society becomes more complex, information skills are becoming an important curriculum in school in order to facilitate students' learning and success. The several information processing models developed by scholars in the field of library and information studies, address the contents of the information skills curriculum. It is promoted that the models be taught throughout schools by using an integrating method between information skills and the other subject areas.

However, because there is a lack of understanding and a great demand upon teachers to teach information skills, it is, therefore, desirable to enunciate and recommend the integrated teaching and learning of information skills.

It is rarely reported that theoretical evidence exists as to why the integrated curriculum of information skills and the other subject fields helps students' learning in terms of developing the students' creativity. The purpose of this paper is to scrutinize

the reasons why the integrated curriculum contributes to the enhancement of students' creativity.

For this purpose, the cognitive theory of Jean Piaget will be analyzed and interpreted in terms of creativity and integration. From analyzing and interpreting this theory, I hope to show there is a structural function that generates creative ideas by integrating different information in human cognition. Also physical evidence of Piaget's assertions will be found in the recent research on the neuronetwork of the human brain. This evidence concurs that the information processing models designed to integrate information have a similar structural function compatible with that of human cognitive processing. It will be the main reason why the information skills curriculum is necessary for improving creative thinking.

I will also try to interpret and emphasize that the information processing model is an important tool to embody human ideas. Tools are not only necessary in the material aspect of our lives, but also in the psychological aspect, especially in this era when information lets the human mental ability dazzle. From this point of view, I will explain the function of the information processing model by invoking Vygotsky's mediation theory and the function of physical tools. The function of a tool helps users leap up to a higher level toward the user's purpose. I hope to show that an information processing model as a tool functions for students to learn how to think creatively.

Lastly, I will configure the reasons why the information processing models are necessary tools for students as well as the integrated curriculum. An information processing model not only gives the effect of integration between information skills curriculum and other subject areas, but also elevates the effect of integration between the different subject areas to a higher level.

2. Creativity and integration

The definition of creativity is so evasive that scholars have different explanations. The most comprehensive and reasonable explanation is in the view of I. Brinck (1997, p.5-16). Brinck's view relates to the very traditional definition that artists with intuition in different fields are creative. Although the intuition of artists has long been regarded as noncognitive and figurative, and thus the opposite of deduction and also of hypothesis-framing and experimentation, apparently the figurative and the literal are not as much opposite as complementary. Even science sometimes relies on the figurative. Recent work on metaphors show how the artists, conceived of in a very general manner as transfers of features across domains, help structure the information we receive from the world around us(1997, p.16). It is said that the intuitive artists with the help of

metaphors articulate information they receive into creative products.

According to M. Belth, metaphors function far beyond the purpose of information transmission as a literal statement of information that we receive from the world. The most significant of these functions is the positing of enlarged contexts within which literal meanings are connected to implications and not taken into account in the explicit literal meanings of a given statement. The other function of metaphors is the development of a context by employing what is familiar to what is unfamiliar or unknown at the moment. Thereafter, the form and the meaning of what we know becomes the form and the potential meaning of what we are seeking to know (1993. p.33). Belth takes Freud's theory of psychoanalytical therapy in which Freud used Sophocles' *Oedipus*, as a metaphor to explain a child's attitude toward the parents (1993. p.34). The Greek drama, a metaphor that was familiar in the contemporary world, functioned to formulate what Freud was seeking to enunciate. Freud's ideas were formed into a creative theory while he was employing the metaphor.

What I want to point out is what exactly happens in Freud's formation of the theory while employing the *Oedipus* story as a metaphor. In this employment, we are sure to recognize some kinds of integration of the implications that the story of *Oedipus* did not take into account in the explicit literal meaning and some ideas of Freud that were unknown in the world at that moment. Through the integration, a new, creative theory that could be thoroughly understood by the people was generated.

In 1962, J. Bruner (p.19-20) already used the term "metaphoric effectiveness" as well as "metaphoric combination" or "metaphoric connectiveness" in explaining the conditions of creativity. In this sense, according to Bruner, there is no doubt of the close relationship between integration and creativity.

Such interpretation of creativity has education tremendous potential for education. H. Gardner (1993) thought the essential characteristics of creativity would emerge more sharply if he were to examine individuals who stood unambiguously within the highest creative ranks. So, he chose and examined seven persons of each domain: Sigmund Freud, Albert Einstein, Pablo Picasso, Igor Stravinsky, Martha Graham, T.S. Eliot, and Mahatma Gandhi.

His conclusion is that creativity is rather an interaction between (1) individuals, with his or her distinctive abilities and styles, (2) the particular domain or discipline of knowledge within which that person works, and (3) the field that the collection of individuals and institutions which offer training, positions and awards in that discipline. (H. Gardner 1993) He reminds the readers of the truth that no one can deny:

To begin with, an individual must learn to lead a life of discipline to master an area, usually by working under some kind of guidance for up to 10 years. Even Picasso and Mozart required lengthy apprenticeships at the hands of their demanding fathers (1995. p.15).

Gardner's description could be paraphrased as follows:

Even Picasso and Mozart were known as gifted geniuses, they were the individuals who experienced the process of creativity (referred to 1); they studied their domain of knowledge for many years (referred to 2); and they were offered training by their fathers(referred to 3). The process that Picasso and Mozart had experienced, gave them the perfect integration between the input image they received from the domains that they worked, in respectively, and their own inner image that had formed through the same integrating process. It is assumed that their creativity was the integration of the images or information that they experienced within their mind.

There are other viewpoints showing the characteristics of human creativity as a process.

In the quest for the psychological touchstone of creativity, associationistic theories of one kind or another have features prominently. With intellectual antecedents that can be traced as far back as Locke(1690), the common thread which has run through these various speculations on the nature of creativity has been the notion that as a cognitive process, the essence of creative thought inheres in the process of bringing disparate mental elements together to form new and useful combinations. (J. Coney and P. Serna 1995. p.109)

S. Mednick defines the creative thinking process as "the forming of associative elements into new combinations which either meet specified requirements or are in some way useful" (1962, p.221). Mednik found from his experiment that the more mutually remote the elements of the new combination, the more creative the process or solution. When asked to supply associates with a concept such as "table," an uncreative individual readily provides obvious responses such as "chair" or "cloth," but the probability of further responses falls off rapidly thereafter. The creative individual, on the other hand, is less closely bound to a small number of dominant responses and is able to produce a broader spectrum of associations, including those regarded as remote (1962. p.222-223).

It is clear that associations which mean integration, especially the individuals' broader spectrum of associations, relate to creativity. Oxman-Michelli asserts that "the process of thinking creatively starts with the assembly of ideas"(1991. p.4). It is enough to anticipate that there are some kinds of integration of ideas in the process of thinking because the thinking starts with the assembly of ideas.

In general, creative or critical thinking includes the core process of inference. The inference, an act or process of inferring, means "the process of deriving the strict logical consequences of assumed premises" (*Webster's encyclopedic unabridged dictionary of the English language*. 1996). In this definition, the premises are interrelated and/or added to one or more ideas of the person who infers because the results are different from the original premises. Needless to say, some kind of integration exists in the process of inferring.

Many other researchers say that creative or critical thinking which produces creativity is an act of problem-solving (Paul Belinger 1994. p. 357 ; Marc Belth 1993. p.26 ; Edward S. Ebert II 1994. p.284 ; James D. Moran III. 1988. p.1 ; J. P. Guildford 1950. p.444-454). The reason why they believe that creative or critical thinking is an act of problem-solving is because the basic attribute of problem-solving is the integration of information which has a direct relation to creativity even though they did not mention this.

There are researchers who agree with the above believing that creative or critical thinking is an act of problem-solving. They usually prefer to use the term "process" that consists of several steps towards a causal conclusion (Paul Richard. [1991] ; Betty Edward 1986. p.2-8).

R. Baumeister and L. Newman studied the mechanisms of inference processes and found five steps of which the last is involved in integration of assorted evidence and implications (1994 p.3). The researchers explain that the immediate implications of certain bits of evidence may follow automatically from the evidence, and the drawing of implications in the decision process can be effectively regulated. People can control how they assemble evidence, how they assess the conclusiveness of implications and how they integrate the implications of various pieces of evidence (1994 p.16).

Among the numerous research articles and books about creativity, one idea by M. Rhodes (1961. p.305-310) that encompasses a whole spectrum of creativity has been widely accepted and is now even invoked without citation (Thomas B. Ward, Ronald A. Finke and Steven M. Smith. 1995. p.9-13). Rhodes thinks that when he has finished a new creative paper he has visualized the key to the secret nature of creativity. Also that secret is that original ideas are the by-products of (1) a human mind grasping the

elements of a subject (2) prolonged thinking about the parts and their relationships to each other and to the whole and (3) sustained effort in working over the synthesis so that it can be embodied or articulated competently (Mel Rhodes 1961 p.305).

Therefore, one of these strands of research pertains essentially to the person as a human being. Another strand pertains to the mental processes that are operative in creating ideas. A third strand pertains to the influence of the ecological press on the person and upon his mental processes. The last strand pertains to ideas. Ideas are usually expressed in the form of either language or craft and this is what we call product. Hereafter, Rhodes refers to these strands as the four P's of creativity: (1) person, (2) process, (3) press, (4) products (1961 p.307).

As readers have can see through this section, scholars describe creativity with different expressions and highlight different aspects of it. They either show that creativity comes from the integration of information or is the end result of the integrated process with the favorable condition of creativity. In short, creativity can be defined as being generated from the integration of information.

3. Evidence of integration in human cognition

In the last section, I explained creativity that comes from the integration of information. In this chapter, I will discuss whether we can really be creative by integrating. If we can be, why is that so? In so doing, the direction we must take to be more creative will be suggested. For this, I will describe Piaget's cognitive development theory that is applied to many fields because of its scientific, logical deployment. From his theory, I will point out the integrating process of human cognition that elevates the cognitive system to a higher creative level.

Also, I will show that recent research findings on the physical neuronal science of the human brain supports the theory of Piaget in terms of integration of information. It will be a description of the structural function of human cognition which has an innate ability to produce creativity.

3.1 Schema theory of Jean Piaget

Jean Piaget (1896-1980) explains that cognitive development of the human being is a process of adaptation in the interaction between an organism and its environment. Adaptation is a process consisting of two complementary processes--assimilation and accommodation. Assimilation is the process of taking in new information and fitting it into a preconceived frame of a concept about objects or the world that is called "schema" by Piaget. Accommodation means that in spite of an organism attempts to

understand a new experience by applying its schema, when this does not work, the organism is forced to change its existing conception of the world in order to interpret the experience (Dorothy G. Singer and Tracey A. Revenson 1996. p.15).

For example, if a child has a concept of a dog having four legs, when the child sees a certain animal with four legs, the child understands that is a dog. The child accepts and understands the image, or information by applying its schema. This process of understanding is assimilation. According to Piaget, "assimilation is the integration of external elements into an evolving or completed structure of an organism" (Jean Piaget 1970. p.706-707).

However, since this assimilation takes place continuously, the schema becomes more generalized and flexible (Antonio Bettencourt. 1989. p.12). That means assimilation generates subsets to fit the schema as a whole and changes the schema itself into a more complex and elaborate one. Then, the schema accepts and understands new information from outside of a subject, and is integrated into the information within the schema of the subject. As a result of the integration, the subject's schema changes into one with more capabilities. This process is called accommodation.

For more a detailed illustration, if the animal with four legs is not a dog, the child's schema becomes confused. That must be a dog because it has four legs, but it is strange for the schema. The child feels something is different from a dog. Eventually, the child realizes the differences, and it is not a dog but a cat because the child's schema has changed to understand the differences. That is new information. This process of understanding is called accommodation. In this simple example, how the child's schema can change to accept new information and realize the differences is not clearly explained.

The following explanation addresses how the child realizes the differences. When the child feels strange, the understanding is not clear about which parts of the image are familiar to the present schema and which parts are not. The animal, as an external world, does not seem formed by a permanent, clear object, and causality is not spatialized or located in the image of the animal. In other words, the external world and the sensations of the child's self are confused. The image of the animal consists in a mobile and plastic perceptual image centered about the child's personal activity (J. Piaget 1937/1995 p.273).

However, it is self-evident that to the extent that this activity is undifferentiated from the image of the animal, the schema constantly assimilates to itself and it remains unaware of its own subjectivity (J. Piaget 1937/1995. p.273). In plain words, assimilation takes place in some parts of the perception through the reciprocal processes, (refers to an interaction between internal elements--schemes and subschemes. J. Piaget.

1975/1985. p.5) and the schema enlarges as much as it assimilates. Then, the child clarifies the parts of familiar and unfamiliar; that means, the child's unawareness becomes smaller. Eventually, the two factors, the image of the animal and the sensation of the child's unawareness, become detached from one another and are organized correlatively (J. Piaget 1937/1995. p.273).

These activities that take place in the schema are the interaction and/or integration of the information that the child perceives and the sensation of the self. These activities also mean the unclear initial understanding becomes clear, and the child's schema expands through accommodation.

Therefore, assimilation, accommodation and integration are the basic integral functions of keeping and developing the structure, the schema. Speaking of the structure, "assimilation is necessary in that it assures the continuity of structures and the integration of new elements to these structures" (J. Piaget. 1970. p.707). Accommodation is necessary to permit structural change, and the transformation of structures (Jack Block 1982. p.282).

The last concept that should be mentioned about the theory of Piaget is equilibrium, which is the end state of the process of integration. Using the above example, the part where the child goes from being unclear to clear is a state of equilibrium that has experienced assimilation and accommodation. According to Piaget, equilibrium, the result of these activities, becomes a sequence of self-regulations since each of the activities consists of correcting the one immediately preceding it (J. Piaget 1970. p.725). "Equilibration is indissociable from construction. It constantly brings about the construction of new forms and at the same time explains the accession of higher-level operatory structures, first to unexpected and finally to necessary status" (J. Piaget 1975/1985. p.138). Equilibrium is continuously self-regulated with changes depending upon the two complementary activities. This is a very interesting point in that the human brain does not necessarily have a separate control system like a computer.

In short, through the process of assimilation and accommodation, the integration of information between the outside world and the inside of the self continuously reorganizes its conceptual frame, the schema, that has potential to grow and generate creativity.

This notion of the integration of information appears in Leo Vygotsky's interpretation about the formation of general concepts. According to him, a "concept does not lie in the human mind like pears in a bag without any bonds between them"(1962. p.110). The "very nature of concepts presupposes a system" (1962. p.111). This system is J. Piaget's schema.

J. Piaget, and his successors are called constructivists after the meaning of their theory. Their theoretical framework offers views of instructional development in educational contexts, that are applied to instructional designs. One of the applications was initiated by Carol Kuhlthau who developed an information processing model (1993).

In the next section, I will discuss physical evidence of Piaget's assertions in the recent research on the neuronetwork of the human brain. This physical evidence will show that the integration of information is the function of the human mind and brain.

3.2 Function and structure of cerebral cortex

The main concern of this section is how the human brain processes information. Does the human brain process information via an integrated method? Is the human information processing system intrinsically constructed to be creative? If the answer is positive, the function of the human brain will parallel the theory of Jean Piaget and his successors.

In cognitive science, the human brain is a system of information processing. Research reveals that the mind, brain, and computer are compatible information processing systems with similar principles. Thinking about human information processing focuses upon the structure and the function of the cerebral cortex, where thinking occurs.

Neuroscientists have thought that the human cerebral cortex is "an elaborate neural mechanism for complex correlations, sensory discriminations and the utilization of former reaction" (Malcolm B. Carpenter and Jerome Sutin. 1983. p.701). The cerebral cortex "confers skill in deriving useful knowledge from the uncertain evidence of our senses, it stores this knowledge, and gives access to it when required" (Horace Barlow 1994. p.4).

According to Barlow, (1994. p.7-8) the neocortex acquires, stores, and utilizes knowledge of the world. A flow diagram (figure 1) shows how perception is accepted

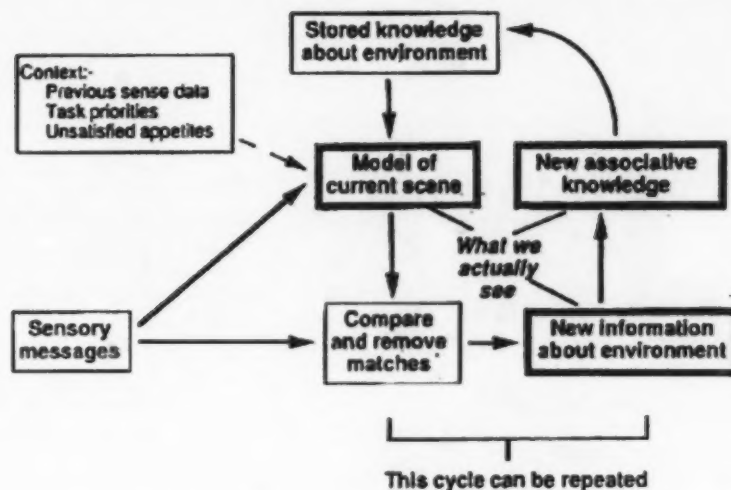


Figure 1. Flow diagram for information within human brain.

Source: Horace Barlow (1994, p.8) with the permission of author and publisher (MIT Press).

and stored. This diagram summarizes how the human knowledge base is enlarged and developed by repeating the cycle of the integrating process of information and by keeping the content of information always new within the cycle.

Sensory messages are combined with a store of knowledge of the world to find the best model of the current sensory scene. This model is then compared with the sensory messages being received, and those parts that match are removed. The residue represents the part of the current sensory input that is unaccounted for by preexisting knowledge, or the "schema," to use Piaget's term. This would correspond to new information (Barlow, 1994, p.8). This new information is processed through accommodation to new associative knowledge that is integrated to become the eventual model of the current scene.

This conceptual flow of information shows that information from outside and inside the brain integrates along the stream of flow. In other words, as soon as the messages from the outside world enter the cerebral cortex, those messages begin to integrate with the information of the knowledge base that is readily modified to another state.

To see concrete information processing in the cerebral cortex, especially in the neocortex, it is necessary to verify how neurons at a single cell level in a neocortex work. Nowadays, owing to highly advanced technology (MRI: magnetic resonance imaging), neuroscience is aiming to find the structure and functions of neuronal cells by analyzing the brain part by part.

A neuron, a component of the neocortex, consists of four components: axon, cell body, dendrites and synapses. A recent article by Koch (1997. p.207) explains a neuron and its functions. Among the four components of a neuron, the function of the synapses is so far known to be the most critical for learning and thinking. Synapses are the specialized connections between two neurons. The connection between neurons is due to synaptic strengths that are modified by a certain condition. The change could either be the formation of new synapses, or the elimination or modification of preexisting synapses (James A. Anderson. 1995. p.146). Moreover, "the more a synapse is used, the stronger it gets"(James A. Anderson. 1995. p.147).

A new study (H. J. Markram et al. 1997) indicates that the order of the arrival time between the presynaptic spike and the back-propagated postsynaptic spike is critical for synaptic plasticity (1997. p.213). If the presynaptic spike precedes the postsynaptic spike, the synaptic weight increases (Christof Koch. 1997. p.209). Increases in synaptic strength appear responsible for the tenacity of associative binding (A. W. Epstein. 1994 p.343).

Increases in synaptic weights mean that synaptic integration has taken place and the information can be conveyed to dendrites and other neurons (H. J. Markram et al. 1997. p.215). Thus, the consequence of the conveyance of synaptic integration "allows the network to form associations over time, enabling it to learn sequences and to predict events" (P. R. Montague and P. Dayan. 1995. p.725-8).

The concrete meaning of an association is formed by linking one item to another. For example, when shown one side of a person or an animal, it is predictable who the person is or what the animal is by using the associative activities through the memory network, a knowledge base, in the cerebral cortex. This example of association is simple, but a human can associate a very high level of speculation.

How the memory network includes the individual neurons where the associations occur will help us understand the spectrum of the thinking activities in the cerebral cortex. There are as many networks as there are memories, and the number is potentially infinite but, of course, many different networks share their constituent element: cells connections (Joaquin M. Fuster 1995. p.97). Anderson depicts the cerebral cortex of a human brain as a highly complex and flexible information processing network. The brain has "complexity in the kinds of cells, their arrangement into layers, and the cross linkages among them" (O. R. Anderson. 1997 p.73).

When neurons become organized into networks with many linkages among them, the possibility of different combinations of neurons to become activated as a unit increases. Hence, given the vast number of neurons, the number of neuronal activation

patterns appears to be sufficient to explain the varied psychological representations of humans (O. R. Anderson 1997. p.74-75).

Hippocampal neurons of neural ensembles "act as members of a distributed network, their ensemble activity embodies or supports memory space" (H. Eichenbaum, T. Otto and N. J. Chohen 1992. p.30). Topographically, the hippocampus is similar to higher cortical areas in that it represents similar items in clusters of cells, but cells coding for unrelated items overlap, suggesting an even more complex organizational scheme (H. Eichenbaum 1993 p.993-994).

In other words, the hippocampus may embody a single, very large functional module that supports a distributed representation of relations among perceptually distinct items (H. Eichenbaum 1993. p.994). The network of the human brain has billions of neurons in the cerebral cortex alone (Constance M. Pechura and Joseph B. Martin ed. 1991 p.4) and it is a marvelous information processing unit with extreme flexibility.

For encoding information in the cerebral cortex, a systematic organization is composed of a hierarchy of "filters" or "detectors" that encodes simple stimulus features and complex events by the activity of single neurons through the hierarchy (H.B. Barlow 1985 as cited in H. Eichenbaum 1993. p.993), and also is composed of a fully distributed representation that encodes each item by distinct spatio-temporal activity patterns of neurons (H. Eichenbaum. 1993. p.993).

Even though the content that is asked is simple such as the name of a person, "the retrieval is basically an associative process" (J. M. Fuster 1994. p.199) through this network. The act of retrieval implements by associative access through memory component representations by reconstruction from fragments, (J. M. Fuster. 1994. p.199) because human memory is basically an associative (M. S. Humphreys et al. 1994. p.666) or connective network (Wolfgan Klimesh. 1994. p.43-50). The association of information during the process of retrieval is empirically proved by experiments with humans as well as animals (J. M. Fuster. 1994. p.201-211. ; Arthur Wingfield and Dennis L. Byrnes. 1981. p.75-87).

During these encoding and retrieval processes, the massive convergence of afferent input and extensive associational connections takes place. These massive convergence and associational connections mean the integration of information.

As a consequence, it is obvious that the human brain works through the integration of information. As shown above, after approaching the flow of information within a brain, looking closely at a single neuronal level, and also observing the neurons as a whole network, it is found that the human brain works through the integration of

information from both outside and inside. This finding in neuroscience has also been tested and confirmed with empirical experiments for a long time in psychology.

This meeting point of two different domains -- psychology and neuroscience -- allows us to understand how the human brain can work most efficiently. If we know the process of thinking, we can use this to enhance our creativity.

4. Function of Tools

In this chapter, I will stress the necessity of tools in human thinking process by applying the functions of tools through invoking Vygotsky's mediation theory and research about physical tools. In doing so, I will try to imply that an information processing model is a prerequisite tool in the context of a thinking process producing creativity.

In fact, the importance of tools in our daily life cannot be overemphasized. "Tool use as the means by which man changes nature and, in so doing, transforms himself" (M. Cole and S. Scribner, 1978, p.7). Vygotsky links this concept of tool use and thinking process:

Vygotsky brilliantly extended this concept of mediation in human-environment interaction to the use of signs as well as tools. Like tool systems, sign systems (language, writing, number systems) are created by societies over the course of human history and change with the form of society and the level of its cultural development. Vygotsky believed that the internalization of culturally produced sign systems brings about behavioral transformations and forms the bridge between early and later forms of individual development (M. Cole and S. Scribner, 1978, p.7).

Vygotsky analyzes how both tool and sign use are mutually linked and internalized in the process of individual development by adopting three characteristics of tools and signs:

The first pertains to . . . common points of the two types of activity. The basic analogy between sign and tool rests on the mediating function that characterizes each of them. . . .

For the second point, a most essential difference between sign and tool. . . . The tool's function is . . . a means by which human external activity is aimed at mastering and triumphing over nature. The sign, on the other

hand, . . . is a means of internal activity aimed at mastering oneself. . . .

Finally, the third point pertains to the real tie between these activities. . . . The mastering of nature and the mastering of behavior are mutually linked (1978. p.54-55).

In the above citation, I want to pay attention to the last paragraph. Humans, by using tools and signs, acquire the mastering of nature and culture (behavior), and then they alter themselves by mastering nature and culture. The development of any aspect of humans comes from the alteration of humans by themselves. This process entails the internalization of human experiences by using tools and signs (1978. p.56-57). It also involves "*higher* psychological function or *higher behavior* as referring to the combination of tool and sign in psychological activity"(1978. p.55). This higher psychological function or behavior, or internalization means integration of information. All the activities in the mind or the brain, whatever they are termed, are basically composed of information.

J. Wertsch interprets if mental processes can be understood only when we understand the tools and signs that mediate them, if we organize the tools and signs very well, we can be understood better than if we don't (James V. Wertsch. 1985. p.15).

Therefore, tool and sign use, referring to the mastering of nature and behavior, is indispensable for the integration of information or internalization of human experiences. Vygotsky's assertion about mediation is now admitted in the education field as well as accepted in using media in-daily life these days.

The mediation that we use in our lives appears as a medium. M. McLuhan who wrote *Understanding Media* in 1964 became famous for saying "the medium is the message." I think that no other expression emphasizes the importance of media better. The book was reprinted in 1994 which indicates that people continue to have resonance with his idea. What is the medium? M. McLuhan explains:

The "content" of any medium is always another medium. The content of writing is speech, just as the written word is the content of print, and print is the content of the telegraph. If it is asked, "What is the content of speech?" it is necessary to say, "It is an actual process of thought, which is in itself nonverbal" (1964/1994. p.8).

Also, we always find a new, useful medium from utilizing one medium:

When IBM discovered that it was not in the business of making office equipment or business machines, but that it was in the business of processing information, then it began to navigate with a clear vision. The General Electric Company makes a considerable portion of its profits from electric light bulbs and lighting systems. It has not yet discovered that quite as much as A.T. and T., it is in the business of moving information (1964/1994. p.9).

The media include physical tools and psychological tools. The psychological tools that McLuhan mentions are writing, speech, nonverbal thought, etc., and the physical tools are office equipment, business machines, electric light bulbs, etc.

Especially on the educational scene, media are mandatory. Without media, teaching and learning cannot occur. R. Clark published a controversial claim that media do not influence learning or motivation, and then issued a "back off retraction" from his argument because of the many disagreements (1991. p.34-39). Those many disagreements strongly show that the role or function of media in education is widely and positively admitted because the function of media can reconstruct and elevate the mind of humans who use them.

The media is so important in our lives because the functions are not simple and one-dimensional. The mind of the human who uses a medium is likened with the "content" of a medium. The medium and mind affect each other in a variety of ways. The medium is, of course, the creation of the mind, but it in turn affects its creator (G. Salomon. 1997. p.380).

L. van Leeuwen and his colleagues (1994. p.174-191) figured out the affordance of a tool by analyzing the function of tool use. According to them, the affordance of a tool is constrained by the integration of several complementary relationships among actor, tool, and target. The function of tool use consists of complementary relationships of three factors.

When using a tool, "the tool-combine-properties relate to both the actor and the object in a manner that allows the actor to handle the object" (1994. p.176). For example, one end of a screwdriver "represents a potential complementarity with a screw (target object); the other end represents potential complementarity with the actor's hand"(1994. p.174). Why a racket is deliberately chosen by the user as a means to an end is because tool affordance (and effectivities) complementarity relates to both the actor and the target (1994. p.176). One meets his or her needs by these complementary relationships.

However, the function of tool use must be explained as more than simple relationships between the three factors. L. van Leeuwen and his colleagues describe the function of tool use in terms of affordances by assuming a higher order structure. A higher order structure means "the mutual constraints as dual relationships between tool and target, tool and actor, and target and actor" (figure 2) (1994, p.176). The researchers realize that the interdependence of these relationships maintains the duality principle, which means a concept of higher order complementarities.

In figure 2, a lower order affordance of the function between tool and actor is influenced by different possible variables, such as the shape, size, texture and other properties of a tool and the shape, size, force (or motor control) and other properties of the actor's system. The relationship of the condition of an actor's hand and the condition of a

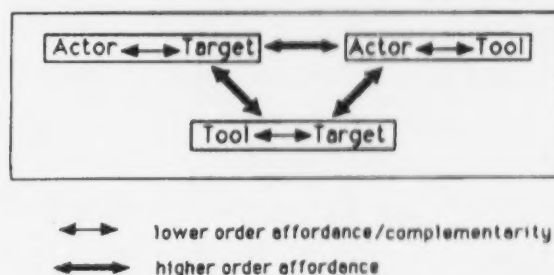


Figure 2. Relationships among actor, tool and target as mutually constraining complementarities in a second-order affordance structure.
Source: L. van Leeuwen et al. (1994, p.176) with authors' permission

screwdriver constrains the lower order affordance between the actor and the tool. Similarly, the other lower order affordances are constrained by the relationships of the conditions of tool and target, and the relationships of the conditions of actor and target.

Based on these lower and higher order affordances, the event of using a screwdriver produces the end that the actor intends to accomplish. In other words, during the process of producing, the lower and higher order affordances are constrained by the complementary relationships with the duality principle. The result of the user's movement amplified by those affordances in the screwdriver use is more than the user's movement itself. The complementary relationships mean, in other expression, the integrated relationships of different factors.

Some similarities to this relationship of physical tools are found in Vygotsky's interpretation of the relationship of speech and thinking in his famous work titled *Thought and language* (trans. by E. Hanfmann and G.Vakar 1962). Vygotsky traces the identity of thought and speech (1962, p.2-7) and says that thought is "speech minus sound"(1962, p.2). Without speech, without mediation, one is not able to express

thought which is the presence of a "generalized reflection of reality," (1962. p.5) or sensation. This generalization of reality or sensation, which means a formation of a meaning or a concept, can take place only by speech, a kind of psychological tool. The thinking, in other words, is implemented by using speech.

It is assumed that this thinking by using speech is implemented by the complementary relationships with the duality principle, similar to the use of a physical tool like a screwdriver. We can induce the same relationships and principle in the psychological universe from the findings of neuroscience. When information is coded in memory, as I cited in chapter 3.2 (p.13), a systematic organization is composed of a hierarchy of "filters" or "detectors" arranged into layers and cross linkages. If we deliberate profoundly about what will happen when retrievals or inferences occur through this hierarchical systematic organization, the complementary relationships with the duality principle must occur.

For example, a human infers with one or more pieces of evidence and derives a conclusion. Even if he or she has one piece of evidence from the outside world, there are several information in his or her brain possibly connected to the evidence. While inferring, his or her brain cells activate to find connections between the pieces of evidence to focus on a certain conclusion. The activation means the variation of synaptic strength in which new synapses, the elimination or modification of preexisting synapses occur (J. A. Anderson 1995 p.146). At this time, in the strings of connections, these variations of changing synaptic strength cause an alteration of equilibrium, which means, new activities for balancing take place and those activities form complementary relationships with the duality principle. These complementary relationships with the duality principle amplify the inferring process to a firm conclusion.

There are complementary relationships with the duality principle in so far as the logically arranged pattern of a system has tenacity of associative bindings, and the system is a higher order affordance structure. Compared with a screwdriver use, the system of the hippocampus is equivalent to the system of screwdriver use (see figure 2) in which several units of connecting parts (tool and target, tool and actor, and actor and target) correspond to the numerous connecting nodes of the items throughout the memory network. The tenacious associative bindings, that are caused by the synaptic strength between neurons, are compared to the hand's movement in the use of a screwdriver. There must be similar lower and higher affordances in the integration of information similar to the lower and higher affordances in the integration of different factors in the use of a physical tool like a screwdriver.

Another example is the chunking concept in the short term memory (J. A.

Anderson. 1995. p.144). This memory does not last long and it has limited capacity in that it can simultaneously retain only a small number of items, commonly accepted as seven, plus or minus two. However, by grouping items together in a process, it is possible to enhance the effective size of the short term memory. In so doing, if we suppose several layers of memory hierarchy, the retrievals will be accomplished by the complementary relationships with the duality principle between the items of information in the short term memory system. This is called the higher order affordance system.

We can see these amplification phenomena in using a very highly complex tool like a computer. The function of a computer, that is supposed to be used with software, is to amplify the user's primary idea. The user's idea integrated with information from the software by complementary relationships with the duality principle, becomes not only more creative than the primary idea, but also frequently goes far beyond the user's expectations.

J. Freedman and her colleagues report on a graduate course using the computer as a tool and medium in creating new media at Johns Hopkins University. They say that the limits of the initial objective statement may be pushed beyond what is feasible to accomplish within the allotted time and budget (1996. p.78). It is obvious that the user's initial objective statement is amplified. The amplification must be related to the complementary relationships with the duality principle.

Why is the result of using a computer obviously more remarkable than using other tools like a drawing or a model? It is that the proper conditions for complementary relationships are regulated between the items of information in the thinking process by the user's control, owing to the computer's distinct spatio-temporal properties. These conditions are most important because these are the only ones that can be regulated by our consciousness¹.

When we deliberate about something, unclear initial inferring becomes gradually clear because we have regulated the condition for complimentary relationships between items of information in our mind or brain. By regulating the variables of condition, the

¹ Many cells in the central nervous system (although not all) have spontaneous activity (J. A. Anderson 1995. p.150); Memory network is self-regulated, autonomic system (O. R. Anderson 1997. p.75); Activities of assimilation and accommodation are self-regulations since each of activities consists of correcting the one immediately preceding it (J. Piaget 1970. p.725). These explanations about the activities inside the mind or brain imply that human consciousness can control only the "conditions" for complementary relationships because the "conditions" are the entities outside of the mind or brain, but cannot directly control complementary relationships between items of information inside the mind or brain.

maximum potential complementarities can be fixed between the items of information. It is similar to the maximum potential complementarities between the several factors in using a screwdriver by regulating hand movements. If we grab a screwdriver in a favorable position or put the other end of the screwdriver to the screw (target) at a right angle, the job will be done much better than if we use it at a different angle. The former case has the proper condition and the latter does not. Therefore, it is important that the user provides the proper conditions for the complementary relationships between the items of information.

The importance of the function of tools in the psychological universe is presented in Vygotsky's mediation theory. Humans live by using physical and psychological tools, and combining the two. Tool use influences human information processing by helping the integration of information that causes creativity within the mind or brain. Tools, if organized very well, allow the user to produce something far beyond the user's expectation. This proper organization of tools requires appropriate conditions which are the only ones we can control in our consciousness. The most outstanding creativity involves the function of tools.

5. Information processing model : a tool to aid creativity

5.1 Integrating characteristics in an information processing model

Having proposed that the integration of information produces creativity, I have scrutinized the cognitive process of the human mind and the information process of the human brain. From this scrutiny, I feel that the mind and the brain might be the same entity that we name in different terms because of research being conducted from different directions.

Information from the inside and the outside of the mind or the brain goes through integration processes and produces new information. That new information is neither the same as the input messages nor as the information from the inside of the mind or brain. Thus the integrated information is always new for the mind or brain. This fact, that the human mind or brain is always constructed to produce new information, implies that anyone can be creative in a general sense. In other words, when the products of the processing of the mind or brain are something that no one has tried before, those products are called inventions, discoveries or findings, and the person is called an inventor, a discoverer, or a finder.

When looking closely at how the human mind or brain processes information in chapter 3, it is noted that the integration of information includes three features as

follows: (1) The information can not be conveyed directly from things, facts, situations, etc. that we perceive from the outside of the mind or the brain into our knowledge base (H. E. Fischer. 1993. p.136, 145). That information is coded into our memory after passing through the process of the integration of information and retrieved through the symmetrical process of it (O. R. Anderson 1997. p.81). During the process, newly united concepts are formed in which each item of the concepts connects into logical associations (section 3.1 and 3.2). (2) The associated information is stored in a clustered manner in our knowledge base (section 3.2). The hippocampus represents similar items in clusters of cells, but cells coding for unrelated items overlap, and the cells create an even more complex organizational scheme. (3) Since the knowledge base is changed according to the coding of the associated information, it can be a highly complicated or an extremely simple organizational scheme. This coding activity indicates that in the absence of obvious inputs, the activities of coding decrease because neurons discharge. From an educational standpoint, this fact reminds us of the necessity for continuous training in thinking activities for students.

I want to compare these three characteristics of the formation and storage of information in the human mind or brain with that of an information processing model developed as a study tool. After comparison, if the model and the human information processing system have a similar pattern, the model can properly help the students' information processing because the use of the model can help the work that the mind or the brain should process. If the model can indeed accomplish this, the evidence of necessity for the information processing model will be provided.

Although there are numerous studies about study skills, there are several outstanding models developed by M. Eisenberg and R. Berkowitz (1990), B. Stripling and J. M. Pitts (1988), C. Kuhlthau (1993), and K. Appleton (1997). Since these models have similar characteristics to those of the information processing of the mind or brain, I have chosen one model developed by Eisenberg and Berkowitz (hereafter Big Six Model) that is widely known.

In order to see the characteristics of Big Six Model, the six steps that comprise the model are enumerated as follows (1990. p.5-9):

Task definition:

Step to determine the range and nature of tasks to be accomplished.

Information seeking strategies:

Step to decide with regard to the range of information sources that are appropriate to meet the defined task.

Location and access:

Step to implement an appropriate strategy. This step is for acquiring the materials of the desired information resources needed to meet the defined task.

Use of information:

This step refers to deciding and extracting the valuable information for the particular situation through the interaction with the individual materials that are acquired at the previous step. The deciding and extracting means taking notes, copying, citing and other techniques after reading, viewing, listening, interviewing and proper activities with the individual materials.

Synthesis:

As such, this step refers to restructuring or repackaging information by using the extracted information and often the organizer's ideas into a new format to meet the requirements of the task as defined. This step also refers to representing the new format.

Evaluation:

This step refers to the examination and assessment of the information problem-solving process with regard to how effectively and efficiently the task was carried out.

The characteristics of an information processing model can be found in the enumerated steps as well as in the whole perspective of the model. I wish to point out two characteristics within the steps and one characteristic of the whole perspective of the model.

First, among these six steps, is there any corresponding concept matching the integrating activity concept of information within our mind or brain (referred to on page 22 in 1)? The Synthesis step is definitely meant as an activity for integrating information. The process of the synthesis of information is actually the most important in the Model since the other steps exist only to support this function. Synthesis is the desired final outcome. In other words, the other five steps contribute to one cycle of integration of information focusing on the prime Synthesis step. The results of each step are used for synthesis which is an integrating activity. If the items of a previous step are clearly defined or analyzed, the next step can be carried out properly and logical synthesis is possible. The use of many steps of the Model, if we see only outward phenomena, seems like analyzing work, except for the Synthesis step which produces one or more concepts by integrating activities.

However, when thinking closely about the process of each step, the results of each

step are consequences of integrating activities that presuppose analysis. For example, in the task definition step, a user must discriminate between the items or areas which belong to the task and the items or areas which do not in order to determine the range and nature of a task. This activity involves analyzing. Then, the user connects the items or areas which belong to the task to one another to define the task. This activity involves integration. However, even at this integrating moment, the user must discriminate between which items or areas are closely related and which items or areas are remote from one another in order to connect them logically. In doing so, the user clearly defines the range and nature of the task.

The integrating activities presuppose analyzing activities while a user works within one step or through the whole process with the Model. Therefore, one cycle of integration of information comprises numerous integrating processes, which are accompanied by the analyzing processes within each step, as well as the whole process of the Model. Also, there are many layers of integration of information and complex connections to form the end results of the Model.

The notion that an integrating activity presupposes analysis is paralleled to the chunking and hierarchy concepts. When a human brain encodes the images that are perceived from outside, the brain must classify or discriminate between the images to fit them into the proper place in the system of chunking and hierarchy even though the system is extremely flexible. This process is accomplished by analyzing, but the whole spectrum of the system, by placing the items of the images into proper places, is also the result of integrating activities. Thus, we see the result of synthesis and analysis in one organized system. This system is similar in principle to a library collection, an organized system, which is consisted of the items that are classified. Classifying library materials includes analyzing work.

The terms assimilation, accommodation and association, used by J. Piaget and other psychologists and neuroscientists, are the concepts that comprise these two process -- analyzing and synthesizing. As shown in section 3, assimilation, accommodation and association are integrating activities. The integrating activities are accompanied by analyzing activities as an inseparable attribute. As such, assimilation, accommodation and association that are implemented through comparison have analyzing processes. In this sense, the Synthesis step also has analyzing activities, even though the portion of analyzing is relatively small. Furthermore, this Synthesis step is actually the last step for the integrating activity. These are the reasons why all the other steps, except the Synthesis step, in the Big Six Model, strongly appear to be analyzing processes.

Therefore, not only during the synthesis step, but also during the other steps, as well

as between these steps, there are numerous integrating activities. Also, assimilation, accommodation or association activities occur within each step as well as through the whole process of the Model.

Second, within the steps of the model, is there any corresponding concept matching the organized scheme of information in our mind or brain (referred to in 2)? It is self-evident that the product of using the model is exactly the same in nature to the memory scheme in our mind or brain because it is organized by synthesizing.

Students should be exposed to multiple resources in order to synthesize different information. If not, the model as well as the mind or brain system cannot carry out their integrating function because of the lack of different information. When the Big Six Model is used, the synthesis is easily emphasized by librarians and teachers "in terms of the organizing of information from multiple sources" (M. Eisenberg and R. B. Berkowitz 1990. p.34). These multiple sources are very meaningful in synthesizing information from different subject areas as well as various media such as books, films, computers and their affiliate media, knowledgeable people and field trips (Arthur L. Costa 1993. p.7).

Even a simple event in human life is related to several subject areas that schools usually teach separately. For example, if a first grader does an errand at the post office for his or her parents, that event is implemented through the use of the knowledge connected to several subject areas such as language, algebra, social studies, ethics, economics, etc. as well as possibly different media. Students learn English through English courses, algebra through algebra courses, social studies through social studies courses and so on. However, they should combine the knowledge that is learned from different subject areas and various media in order to use the knowledge and solve problems in either school assignments or in actual life situation.

Thus, it is safe to say that the effect of integrating information by using an information processing model extends not only to organizing the knowledge within one subject curriculum area but also across different subject curriculum areas and different media. In this sense, the information processing model also contributes to the whole language approach at the K-12 levels and the upper levels.

Third, is the result of using the model dependent upon how properly and frequently it is used? Is it similar to how the human information processing (thinking) system changes depending upon how the encoding occurs? (This comparison is referred to on page 32 in 3). The answer is positive because the use of the model is directly related to the activities of the user's information processing skills. The fact that information is being integrated by using a model, represents the activation of the user's inner skills for

information processing in his or her mind or brain. If a user uses the model frequently, his or her information processing system experiences more often how to organize different information.

Therefore, using a model properly and frequently means the strengthening and enhancing of skills regarding the integration of different information in the thinking system. Also, the more the model is used, the better the organizing skill of different information in the human mind or the brain is elaborate. Accordingly, the better the skill in using the model, the better the product. The highly trained thinking system (knowledge base) has a high probability of producing creative products, because it can integrate information more elaborately.

As I have postulated in the beginning of this chapter, these similarities provide the feasibility on the reason why the information processing model is necessary for K-12 and even higher levels of students in school situation.

5.2 Characteristic of an information processing model as a tool

On the other hand, I have also studied tools. According to Vygotsky, humans master nature and culture (behavior) by using physical and psychological tools, namely signs, mediation or media. The mastering of nature and culture in turn changes the humans themselves. This also involves the integration of the information of nature and culture, and the information of the self who masters them at the moment. Consequently, the use of tools shapes or controls some important parts of human change. The media, as McLuhan asserts, are the message and also tools that affect human change. These changes by the use of tools has gradually become clear as a truth in this era when advanced technology affords humans to break their limitations endlessly.

Also, after I have studied the concrete function of a tool, I found the event of tool use is implemented not only by the integrated or complementary relationships of the different factors but also by the duality principle. Similar to this physical tool use, it is assumed that human information processing is also implemented by the complimentary relationships with the duality principle between the items of the information that are connected by tenacious bindings (A. W. Epstein 1994. p.343) through numerous layers and linkages (O. R. Anderson 1997. p.97) of the memory network. Since the tenacity of associative bindings is caused, increased, decreased or vanish according to the variation in synaptic strength (A.W. Epstein 1994. p.343), when these activities occur at the same time in a string of connections, the pushing and pulling activities take place between items of information which try to keep in balance. There must be complementary relationships between items of information.

The information processing model is a kind of a tool. It is molded for the integration of information. When using the model, a user does an activity of focusing on a certain concept that is supposed to be logically organized. At the same time, the user regulates certain favorable conditions for the complementary relationships between the items of information that are connected within the user's work. The regulation of conditions is equivalent to the different possible variables of a screwdriver, such as shape, size, texture, etc. and the grasp, size, force, etc. of the actor's hand in physical tool use. Even though these phenomena are not seen outwardly because they occur in the user's thinking, an invisible entity, the complementary relationships between the items of information exist.

Figure 3 shows the computer technology tools that regulate the conditions which help complementary relationships between the items of information within the mind or brain when doing each step of the Big Six Model. If the conditions are favorably set by using tools, the complementary relationships work very well and produce desirable results of integration of information. For example, in the Use of Information step in the Big Six Model, if a user cuts a paragraph or an image and pastes it in another place, and later in the Synthesis step, if the user inserts the paragraph or image in the context of a different text or images by using word processing or other methods, the user regulates favorable

The Big Six Information Problem-solving Processing with Technology Tools

big six	technology
• Task Definition:	electronic mail listservs, newsgroups problem-solving software
• Information Seeking Strategies:	online library catalogs magazine/newspaper indexes World Wide Web (WWW) Gopher full-text electronic resources
• Location & Access:	online library catalogs magazine/newspaper indexes WWW browsers (Netscape, Microsoft Explorer) WWW search engines (Yahoo, Lycos, InfoSeek) Archie, Veronica
• User of Information:	cut/paste down loading uploading

- Synthesis:
 - word processing
 - presentation software
 - electronic spreadsheets
 - database/file management systems
 - Web page (HTML) authoring
- Evaluation:
 - electronic mail (e-mail)
 - spell/grammar/style checkers

Figure 3. Sources: *Helping with homework : a parent's guide to information problem-solving* by M. B. Eisenberg and R. E. Berkowitz (1996) p.97 with authors' permission

conditions for complementary relationships between the items of information in the user's mind or brain. These complementary relationships caused by the regulated conditions produce the best results of integration of information. This integration is in the user's mind or brain. So, the user gets two results: one result of integration is in his or her mind or brain; the other result of integration is outward physical output. These are not exactly same.

I believe there should be some kind of complementary relationships when an organized system, with certain force of cooperation between the components, activates. If the system is also organized with multiple layers and linkages, the duality principle must also be present. Accordingly, we need to regulate the conditions for the complementary relationships with the duality principle for the system to work efficiently.

Therefore, the contribution of information processing models to the integration of information within the mind or the brain makes the model a powerful tool because this tool allows us regulate those conditions. Using a model means the regulation of the conditions for the complementary relationships with the duality principle that causes integration of information, which produces creativity. This integration of information sometimes creates marvelous products that no one has tried before.

Finally, I have described two ways of integrating information within the mind or the brain when using the information processing model. One way is explained by the similarity of the structural function of the information processing model and the human information processing system. The other is explained by the premise that information processing model as a tool provides favorable conditions for complementary relationships with the duality principle which are the force for the integration of information within the human mind or the brain.

The former description is about the use of the information processing model giving the basic framework for the integration of information and the latter is about the model's

concrete contribution to the integration of information within this framework.

6. Conclusion

Postulating the necessity of information processing models for the enhancement of students' creativity, I have studied the structural function of the human mind and the brain, and also the function of tools. The result of this study proves that information processing models are necessary tools for students.

In discovering the evidence of this necessity, I have discussed that creativity, the purpose of education, comes from the integration of different information which exists both in the human thinking process as well as the information processing model when it is used. Thus, the function of the information processing model and that of the information processing (thinking) system of the human mind or the brain are similar. Accordingly, the former can help the latter perform effectively and efficiently if it is used properly.

This proposition is proved by J. Piaget's cognitive theory and the recent findings of neuroscience as follows:

- (1) In terms of organizing information, the information processing model's method of synthesizing information resembles the way that the mind or the brain integrates information when it is assimilating and accommodating, or encoding information.
- (2) In terms of products of the information processing model, the end result is similar to the state of equilibrium of the human thinking process that is logically associative.
- (3) The repeated use of the models is directly related to synthesizing skills in the human information processing system. Since the skill for synthesizing information in the model is the same as the skill of the user's thinking system, the use of the model represents the activating of the user's synthesizing skill in the thinking system. It is different from other functions such as memorizing. The proper and frequent use of the model means the strengthening and enhancing of the skills of the human information processing (thinking) system. This interpretation, including the above (1) and (2), provides the rationale for why students should always use an information processing model when they study or in comparable situations.

On the other hand, humans master nature and culture (behavior) by using psychological and physical tools. Mastering of nature and culture also changes humans themselves, according to Vygotsky. His assertion supports the idea that the human thinking process is influenced by tool use.

How tools influence human information processing is understood by the functions of tools. In order to understand the function of tools, an affordance of tool use is

introduced. The affordance is composed of several complementary or integrated relationships with a duality principle.

This means that tools allow one to amplify the force from complementary relationships with the duality principle toward the purpose of user. These complementary relationships with the duality principle are assumed to exist not only in the physical universe, but also in the psychological universe.

Vygotsky's explanation of the function of speech is an example of the function of psychological tools. Speech as information involves the connections between the different items of information and contributes to the formation of general concepts within the mind or the brain.(e.g. the degree of generality: plant, flower, rose). The example of computer use shows that the tools (software) convey ideas to the human mind or the brain and amplify the integrating activities of different items of information in the same way that speech produces new concepts.

The concrete meaning of amplifying by using software involves regulating the potential conditions for complementary relations with the duality principle to the optimum level. In the case of speech and of computer use, if the speaker or the computer user consciously regulates the conditions for the complementary relations within the mind or brain, the complementary relationships will work under the proper conditions just like the hand's position to the screwdriver, the angle of the screwdriver to a screw, or other conditions for the screwdriver use. We regulate only the conditions for complementary relations with the duality principle because these conditions are the only ones we can manipulate through our consciousness. The integrating functions within the mind or the brain are the functions of the autonomic nerves (J. Coney and P. Serna 1995, p.127).

Therefore, the regulation of proper conditions for complementary relations with the duality principle within the mind or brain is most important. These conditions influence the integrating process of information. The result of this is creativity, as mentioned in chapter 2. Thus, the best tool must afford users to regulate the conditions for the complementary relationships with the duality principle in order to enhance integration of different items of information. Also the training for regulating conditions' variables is important in order to improve the skills of integrating different information.

Since the integration of different information is critical in generating creativity, it is necessary for students to be exposed to a multi-information environment. In school situations, if students are not exposed to a rich, multi-information environment, though they may use the information processing models, the function of integrating different information of the models and the human information processing system both may not

be carried out due to the lack of the rich, multi-information. The multi-information environment for students means an integrated curriculum which includes library and information skills and one subject area or more subjects areas. This is the reason why we should emphasize the necessity of information processing model as a core content area of an integrated library and information skills curriculum.

When we think about the origin of human nurturing, the education of the *whole* person must nourish students' human experiences that take them "beyond the boundaries of analytical thinking . . . to connect them with the creative unfolding of life itself." (R. Miller. 1991. p.58). From this point of view, the information processing models are necessary tools for nurturing students' creativity.

In closing, I feel that more research in the area of information processing models or integrated library and information skills is needed in order to fulfill the goal of educational democracy which means equal opportunities for everyone. Some might doubt "if humans are born and bred to think creatively by integrating information, is there any necessity to learn how to organize information by using an information processing model?" To answer this question, a more philosophical and philanthropical approach to research will be needed because humans are individuals with different characteristics and abilities in different situations of time and space, which imply various range of advantages and disadvantages.

These information processing models and library and information skills are for all, not for just elite academic group alone. Thus, we should teach these tools at the K-12 grade levels and with an integrated method, not through a separate curricula. In doing so, we can expect the "autonomous influence on the participation in education activities" (P. Belanger. 1994. p.360) for all the people in the nation.

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Abstracts:

The purpose of this paper discloses that information processing models are necessary tools in order to enhance students' creativity. Postulated creativity is generated from integration of information, the author discusses about the function of human mind and brain by studying Schema theory of Jean Piaget and the human cerebral cortex. The author then, discloses the function of human information process (thinking process) is an integrating process of information within the mind and brain.

Also, the author describes the function of tools by invoking Vygotsky's mediation theory and the use of a physical tool, and finds that the function of tools influences the integration of information within the human mind and brain.

Lastly, the characteristics of information processing models are compared with those

of the human mind and brain, and proves an information processing model and the human mind or brain have a similar function. Consequently, an information processing model as a tool is revealed to help the integration of information within human mind and brain that produces creativity.

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